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ANNUAL MEETING
THE RADIOLOGICAL SOCIETY

December 15, 16, 17, 1920
Chicago

The next annual meeting of the Radiological Society will be held in Chicago, December 15, 16, and 17, 1920. Headquarters—Hotel Sherman.

The committee on local arrangements are: Dr. B. H. Orndoff, Chairman; Dr. Mary Hanks, Dr. Maximilian J. Hubeny, 25 E. Washington St.

Committee on Commercial and Plate Exhibit: Dr. I. S. Trostler, Chairman, 615 Garfield Ave.

The executive committee of the Society wishes to announce that owing to the difficulty arising from the constant shortage of hotel facilities in Chicago, they have assured the hotel management that they would endeavor to have the members and guests make reservations as far in advance of the dates of the meeting as possible. If this matter is attended to promptly, a great deal of confusion will be avoided.

The program committee wishes to announce that they have under way the arrangement of a program embodying some new and very interesting features together with the usual scientific sessions and social functions.

ROENTGENOLOGY OF TUBERCULOUS ENTEROCOLITIS*

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The early symptoms of ulcerative tuberculous colitis are not sufficiently characteristic to make possible a definite clinical diagnosis, even in the presence of pulmonary tuberculosis. If any benefit is to come from treatment it is imperative that the disease be recognized early, and for this recognition the roentgen ray furnishes the most certain means as yet available. A positive and independent roentgen diagnosis of tuberculous colitis is difficult, however, for there are no pathognomonic roentgen signs, as the filling defect and the absence of the normal barium shadow in the cecocolon are signs of any ulcerative lesion. Even the finding of *Bacillus tuberculosis* in the stool is of no value in determining the nature of the lesion in the intestine unless a tuberculous lesion in the lungs or *Bacillus tuberculosis* in the sputum can be excluded. Every patient with indefinite abdominal complaint should, therefore, have a complete roentgenologic and general clinical examination. Tuberculosis has such a predilection for the ileocecal coil that a lesion in this part of the intestine, especially if associated with pulmonary tuberculosis, is most likely tuberculosis. Distal segments of the colon are seldom invaded; the disease almost always involves the proximal portion, especially the small bowel, ileocecal valve, cecum, appendix, and ascending colon (Brunner). Necropsies have demonstrated that from 70 to 90 per cent of persons suffering with ad-

*Presented before the Omaha Roentgen Society, Omaha, March 27, 1920. Published in part in the *Journal of the American Medical Association*, Volume 74, No. 20, May 15, 1920, page 1371.

vanced pulmonary tuberculosis have tuberculosis of the intestine.

In reviewing the physiology of the colon, the following facts should be kept in mind for a better understanding of the abnormal colon: The cecum and ascending colon form a pouch-like expansion of the proximal part of the large bowel. Their walls are thinnest and therefore weakest and capable of great distention. The interior depressions of the cecum correspond with the surface haustra. It is definitely known that food remains in this portion of the colon longer than in any other, and it is thought that this delay is largely due to haustration and antiperistalsis. With these physiologic functions in mind, it is not difficult to understand how their loss by disease explains the emptiness and gap in the physiologic barium shadow seen in ulcerative diseases of the colon. The bowel contents pass with abnormal rapidity, because the normal functions which retard the physiologic progress are absent.

Pathology of Tuberculosis of the Intestine

The pathology of tuberculosis of the intestine may conveniently be divided into three types: (1) Nodular, (2) ulcerative, and (3) fibrous.

In the nodular type the lesion is made up of conglomerate tubercles which are principally extralumenal in their earliest stages. The nodules are not infrequently seen alone, apparently unaccompanied by tuberculosis elsewhere; they may rarely be seen in association with chronic ulcerative tuberculous ileocolitis, and in such case may be the sequel of pulmonary tuberculosis. This type can hardly be recognized roentgenologically unless it produces obstruction or encroaches on the lumen of the bowel.

The ulcerative type is frequently associated with the nodular, but in a typical instance ulcerative tuberculous colitis is the primary lesion. However, it is possible for tuberculosis to be associated with it in other parts of the body. This type is evidenced by irregularity of bowel contour in the roentgenogram; in the terminal stages it produces obstruction.

The fibrous or hypertrophic type of tuberculosis is manifested by a marked increase of fibrous connective tissue; the tubercles are discrete and relatively sparse. The large amount of fibrous tissue indicates a marked resistance on the part of the individual. It is the terminal stage of healing tuberculous colitis and pericolitis. This type gives practically the same roentgen picture as the ulcerative.

Technic of Examination

The technic of the examination is not difficult. In fact, it is the same as is used for all other diseases of the intestine. In the Mayo Clinic the enema is ordinarily employed; when necessary the ingested meal is used; in a few cases both methods may be necessary. The enema is preferable since it demonstrates small irregularities of contour by actually outlining the bowel wall, whereas the ingested meal is so unevenly distributed throughout the normal bowel that its irregularity cannot be distinguished from that due to disease. This is especially true in cases in which there is little involvement. If the enema is employed, the colon is filled under observation up to and including the cecum. If the ingested meal is given, observations of the intestine with the screen are made at intervals from the sixth to the eighteenth hour. Roentgenograms are made as a matter of record and for study.

Roentgenologic Signs of Tuberculous Colitis

The roentgenologic signs of tuberculous colitis are: (1) Filling defects; (2) spastic phenomena, and (3) obstruction.

The first and most important roentgenologic sign of tuberculous ileocecal colitis is the filling defect, which is due to the ravages of the disease plus spastic manifestations. It is best seen during the screen examination with the opaque enema. Under pressure of the enema the cecum and ascending colon are seen to fill irregularly and are de-

cidedly narrowed in their transverse diameter. The normal haustral markings are absent and Bauhin's valve is usually incompetent. After the pressure of the enema is relieved by shutting off the flow, the involved area usually empties and remains emptied while the remainder of the colon may retain the enema for some time.

The filling defect and the localized absence of barium shadow in the cecum and ascending colon are not entirely characteristic of tuberculous colitis; I have seen them in ulcerative carcinoma of the cecum and chronic ulcerative colitis. Stierlin has reported a case of carcinoma in the ileocecal coil with similar findings. Nevertheless, a lesion of the cecum and ascending colon without the physiologic barium shadow should always suggest the possibility of tuberculosis, and tuberculosis should be looked for in other parts of the body, particularly the lungs. If tuberculosis can be definitely demonstrated in the lungs, the lesion of the cecocolon, whether there is an absence of the physiologic barium shadow or not, is most likely tuberculous colitis.

Hypermotility has been emphasized by Brown and Sampson as an important roentgenologic sign of tuberculous colitis. The term hypermotility can hardly be applied to this phenomenon because, strictly speaking, hypermotility refers to the passage of bowel contents, at an increased rate, along the entire alimentary canal as is often seen in diarrhea and achylia. Fifty per cent of our patients with tuberculous colitis suffered from constipation or delayed motility. In the more advanced cases with diarrhea hypermotility was noted. The gap in the barium shadow, I believe, does not represent hypermotility, but is the effect of diffuse infiltration of the bowel wall which produces rigidity of the part of the intestine affected. It is apparent from this that the physiologic functions of the diseased segment of the colon have been lost and the barium passes through it without hindrance, just as it does through a stomach diffusely infiltrated with cancer. In the absence of diffuse infiltration, spasm stiffens the walls giving the same motoric effect.

Béclère and Mériel state that an ulcerated mucosa manifests its irritability by an exaggeration of muscular peristalsis with an abnormally rapid progress of the contents of the intestine. I have never observed this muscular peristalsis, but I have seen marked spasm of the musculature of the colon due to irritability from an ulcerated mucosa, and I am inclined to think that Béclère meant spasm when he said peristalsis. Stierlin is evidently of the same opinion for in discussing the same subject he mentions no acceleration of motility. Indeed, it has been demonstrated in operations, when the patient is under the influence of narcosis, that this spasmodic condition does exist and its extent is in proportion to the extent of the lesion. For example, if a small solitary lesion is present the spasm is localized and may be analogous to the incisura seen in gastric ulcer. In this early stage of the disease usually there is no gap in the barium shadow of the ingested meal, but the irregularity of contour due to spasm may be visualized by the opaque enema even if the lesion is not demonstrable.

Stierlin, in 1911, first pointed out the absence of a physiologic barium shadow in the cecum and ascending colon in tuberculosis of the ileocecal coil. Much to his surprise, at a time when normally he expected to show the cecum and ascending colon in the roentgenogram, no shadow was visible; in its advance the shadow seemed to skip the cecum and the ascending colon. In this country Pirie was the first to notice this phenomenon. By observations at half-hour intervals, continued for from four to twelve hours, he was able to prove that the tuberculous cecum does not retain the barium which normally accumulates there.

Spasm is a manifestation which to a greater or less degree accompanies many if not all gastro-intestinal lesions. It is one of the most perplexing conditions with which the roentgenologist has to deal. For instance, lesions so slight as to cause no irregularity of contour demonstrable in the roentgenogram may exhibit marked deformity and narrowing due to spasm. Indeed, the absence of barium from an

involved area of the bowel is caused usually by spasm and infiltration of the intestine rather than by hypermotility. This type of spasm is intrinsic in origin and constant in situation; it is present at a second examination and cannot be effaced by antispasmodics.

In our cases tuberculosis has been more frequent in the small than in the large bowel. The lesions are seen most often in the ileum and the jejunum, but the latter is less frequently affected. They occur in the bowel anywhere from a few inches to one foot or more apart and usually become confluent near the ileocecal valve. The affected areas are not more than one-half to three-quarters of an inch in width. They are slightly elevated, may or may not be studded with tubercles, and involve the entire circumference of the intestine. Palpation of the areas reveals the presence of ulcers in the mucosa.

The roentgen diagnosis of tuberculous enteritis is less certain than that of tuberculous colitis. This is probably due to the physiologic and anatomic difference between the small and the large intestine. The obstruction which is occasionally noted is not characteristic, for it is observed in other pathologic conditions. However, I have observed another sign which may have diagnostic value, namely, delay with irregular filling and segmentation of the small bowel; but further study will be necessary to establish this fact.

Summary

A lesion roentgenologically demonstrated in the ileocecal coil, with irregularity of bowel contour and without the physiologic barium shadow in the cecocolon, although it may represent any ulcerative process, is probably tuberculous if pulmonary tuberculosis is present.

The tuberculous lesions may be nodular, ulcerative, or fibrous; they are usually associated to a greater or less extent, dependent on the stage of the disease. The nodular type is recognized by means of the roentgen ray only if it

encroaches on the lumen of the bowel, and the ulcerative and fibrous types by irregularity of contour, and in the terminal stages by obstruction.

The presence of spasm must not be overlooked since it often causes irregularity of contour and is diagnostic even when the lesion itself is not demonstrable.

The opaque enema generally is preferable to the ingested meal in demonstrating the filling defect and spastic phenomena which are roentgenologic signs of tuberculous colitis. In tuberculosis of the small bowel the ingested meal only can be used. A gap in the physiologic barium shadow of the cecocolon in the more advanced cases is demonstrated by the ingested meal, but unquestionably the disease will be demonstrated earlier by the enema.

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Illustrative Cases

Case 285818.—A woman, aged 20, in 1918 had had fever, cough, night sweats, loss of weight, weakness, and pain in the abdomen; no diarrhea.

X-ray Findings.—August 23, 1915. Pulmonary tuberculosis with compression of the left lung. Stomach negative. Colon: irregularity and narrowing of the ileocecal coil (Fig. 1).

Surgical Findings.—Intestinal tuberculosis. There was

a tumor mass in the cecum and the entire length of the ileum was studded every three to six inches with tuberculous nodules, some of them producing slight obstruction.

Operation.—Closed as exploration.

Case 276488.—A man, aged 36, had general abdominal pain, commencing two years before examination, lasting from five to six hours at a time, and relieved by bowel movements. Appendectomy was done elsewhere in September, 1918. Very severe attack came on six weeks after the operation with nausea and vomiting. By dieting he was free from pain until May, 1919, then intermittent diarrhea and constipation. Pain not localized, and relieved by bowel movements.

X-ray Findings.—June 23, 1919. Pulmonary tuberculosis. Stomach negative. Colon: filling defect in the cecum, narrowing and irregularity with eighteen-hour retention in the terminal ileum (Fig. 2).

Surgical Findings.—Tuberculosis of the cecum and ileum.

Operation.—Resection of the right half of the colon with twelve inches of the ileum.

Pathologic Report.—Tuberculous ulcer of the ileum 8 cm. from the ileocecal valve.

Case 161981.—A man, aged 28, had had an appendectomy elsewhere in 1913. A tumor was removed from the cecum, elsewhere, in 1914. Previous to the first operation the patient had three attacks of pain in the right lower abdomen with nausea. After operation he was relieved for eleven months. In 1915 he had attacks of pain, distention, nausea, and vomiting, at first from one to three weeks, now every day. Tumor mass in the right iliac fossa for six months.

X-ray Findings.—June 7, 1916. Pulmonary tuberculosis. Stomach negative. Colon: filling defect in the cecum (Fig. 3).

Surgical Findings.—Large tuberculous tumor of the cecum, involving about one foot of the ileum.

Operation.—Resection of the right half of the colon.

Pathologic Report.—Tuberculosis.

Case 77400.—A woman aged 38, had had pain in the abdomen with vomiting for a long time and almost constantly for the last four months.

X-ray Findings.—October 13, 1913. Small bowel, markedly dilated, indicating intestinal obstruction (Fig. 4).

The patient returned ten months later, with the same symptoms as before; she had had diarrheas for the past three months. The *x*-ray findings were the same as before.

Surgical Findings.—Localized tuberculosis involving upper jejunum about six feet from its origin.

Operation.—Resection of twelve inches of the upper jejunum, anti-peristaltic lateral anastomosis.

Pathologic Report.—Tuberculosis (Fig. 5).

The patient returned in 1917, at which time the examination revealed pulmonary tuberculosis.

Case 311436.—A man aged 28, had had an attack of pleurisy four years before examination. He was well until the fall of 1919, when he developed a morning cough accompanied by prostration. Three weeks later he commenced to have two loose foul smelling bowel movements daily with colicky pain in the lower abdomen relieved by bowel movements.

X-ray Findings.—April 7, 1920. Pulmonary tuberculosis with cavitation. Stomach negative. Colon, filling defect in the cecum (Fig. 6).

Clinical Findings.—Pulmonary tuberculosis and intestinal tuberculosis. The lung involvement was considered too extensive and active for surgery.

Case 161810.—A man, aged 37, for the last eight months had had tenderness in the lower abdomen, gradually becoming localized on the right side. Constipation was becoming more marked. A small palpable mass in the region of the cecum was explored elsewhere, and a diagnosis of carcinoma was made.

X-ray Findings.—June 6, 1916. Filling defect of the cecum (Fig. 7).

Surgical Findings.—Tuberculosis of the cecum.

Operation.—Resection of the right half of the colon.

Pathologic report.—Tuberculosis.

Case 282377.—A man, aged 21, began to lose weight after influenza in July, 1918. In February, 1919, he had a hemorrhage from the intestine. One month later he had pain in the lower abdomen, one attack each week until June, when it became constant. Diarrhea commenced in July, from six to eight stools daily. There was general diffuse tenderness over the lower abdomen, more marked on the right side.

X-ray Findings.—August 5, 1919. Chest and stomach negative. Filling defect on the inner and the outer aspects of the ascending colon (Figs. 8 and 9).

Surgical Findings.—Tuberculosis of the cecum and ascending colon; tuberculous lesion of the lower end of the ileum.

Operation.—Resection of three feet of the ileum, entire cecum, and ascending colon, and half of the transverse colon.

Pathologic Report.—Tuberculosis.

Case 268368.—A woman, aged 50, had had a tumor of the intestine excised elsewhere in September, 1918.

X-ray Findings.—April 25, 1919. Chest and stomach negative. Filling defect in the cecum (Fig. 10).

Surgical Findings.—Tuberculosis of the cecum and terminal ileum.

Operation.—Resection of the ileocecal coil.

Pathologic Report.—Tuberculous ulcers in the mucosa of the cecum and terminal ileum.

Case 310140.—A man, aged 21, began to have trouble two months before with diarrhea, cramps, fever and cough. Tuberculosis bacilli were found in the sputum. Pain in the abdomen occurred about half an hour after eating; he had diarrhea (from two to three watery movements daily).

X-ray Findings.—March 25, 1920. Pulmonary tuberculosis with cavitation. Stomach, negative. Colon, filling defect in the cecum and ascending colon (Fig. 11).

Clinical Diagnosis.—Pulmonary and intestinal tuberculosis, involvement too extensive for surgery.

Case 253143.—A man, aged 25, eight months before examination had developed pain from one-half to one hour after eating, which was relieved by vomiting.

X-ray Findings.—December 14, 1918. Stomach, six-hour retention with marked dilatation and writhing of the duodenum. Obstruction high in the jejunum (Figs. 12 and 13).

Surgical Findings.—Large mass of caseating tuberculous glands obstructing the third portion of the duodenum.

Operation.—Posterior gastro-enterostomy.

Pathologic Report.—Tuberculous glands.

Case 283098.—A woman, aged 28, had had an appendectomy in 1916. Five years before, this abdominal pain with vomiting and at times diarrhea had occurred.

X-ray Findings.—August 9, 1919. Pulmonary tuberculosis with cavitation. Stomach negative; colon, filling defect in the cecum and ascending colon. Absence of a physiologic barium shadow in the cecocolon (Figs. 14 and 15).

Surgical Findings.—Tuberculosis of the cecum and ileum. Scattered throughout the entire ileum at intervals of from five inches to one foot were areas indicative of tuberculosis of its mucosa, producing slight narrowing. Because of the extent of the lesion resection did not seem indicated.

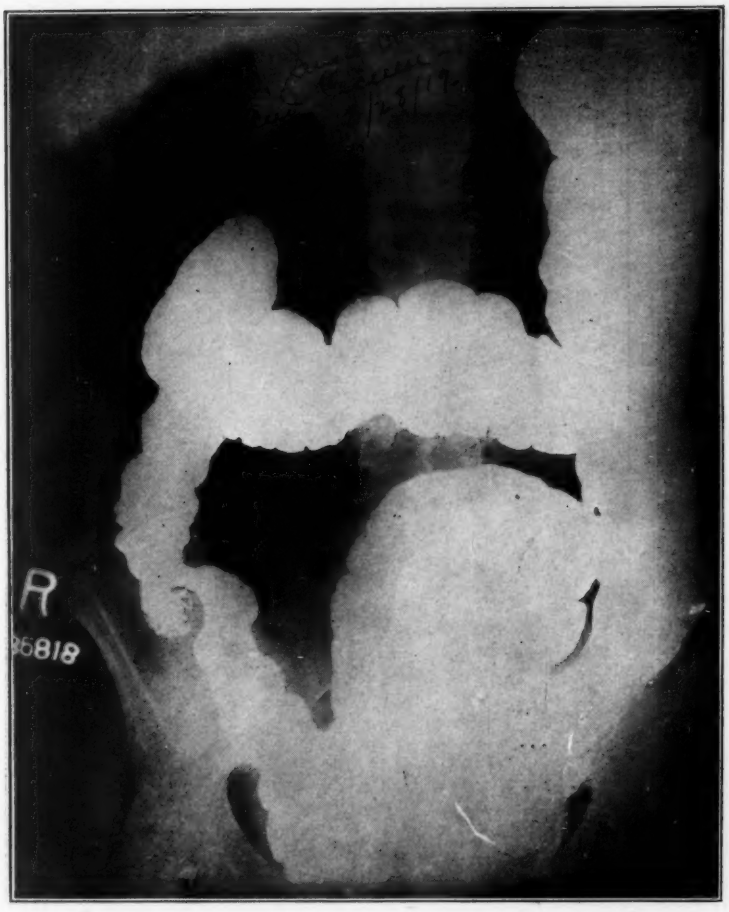

FIG. 1. (Case 285818.) Tuberculosis of the ileocecal coil. Irregularity of cecum and ascending colon at "a".

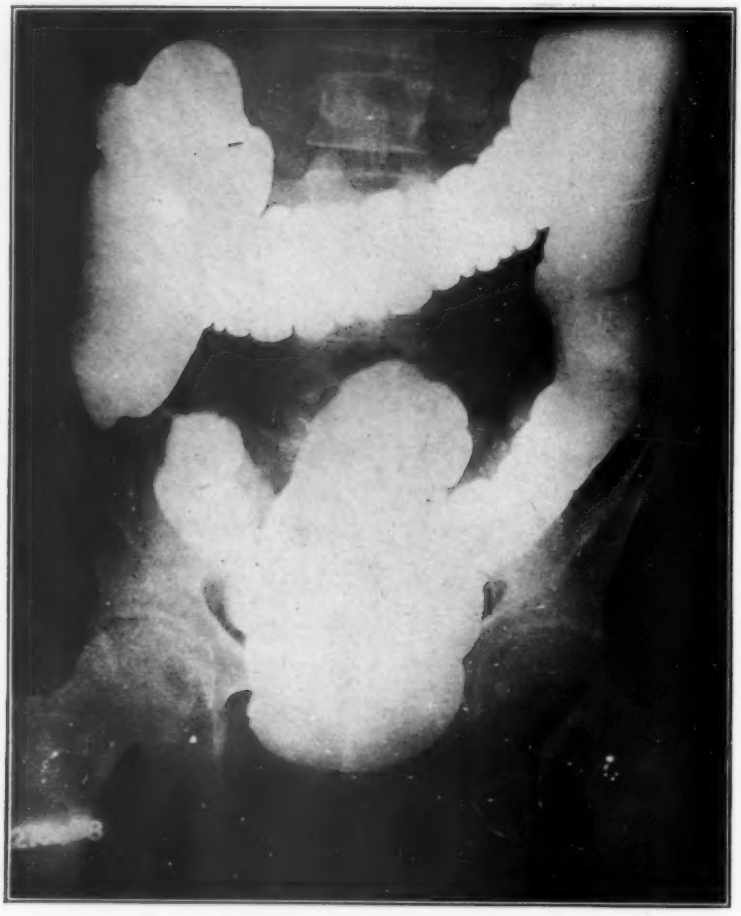

FIG. 2. (Case 276488.) Filling defect in the cecum, narrowing and irregularity of the terminal ileum at "a".

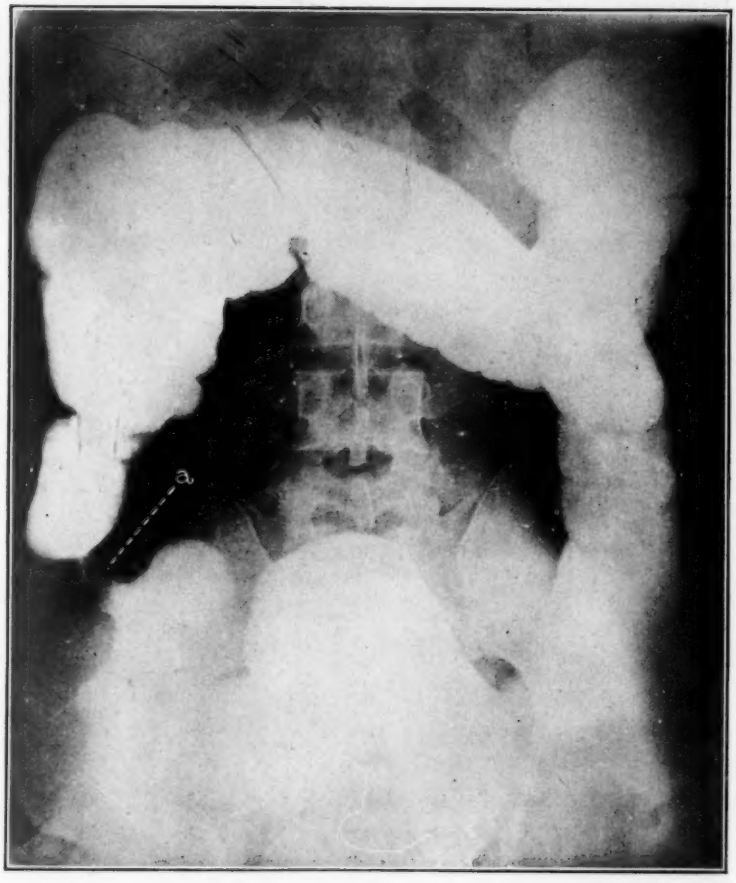

FIG. 3. (Case 161981.) Filling defect in the cecum at "a".

FIG. 4. (Case 77400.) Small bowel markedly dilated. Small six-hour retention in the stomach.

FIG. 5. (Case 77400.) Specimen same case as Fig. 4. Fibrous tuberculosis of the jejunum.

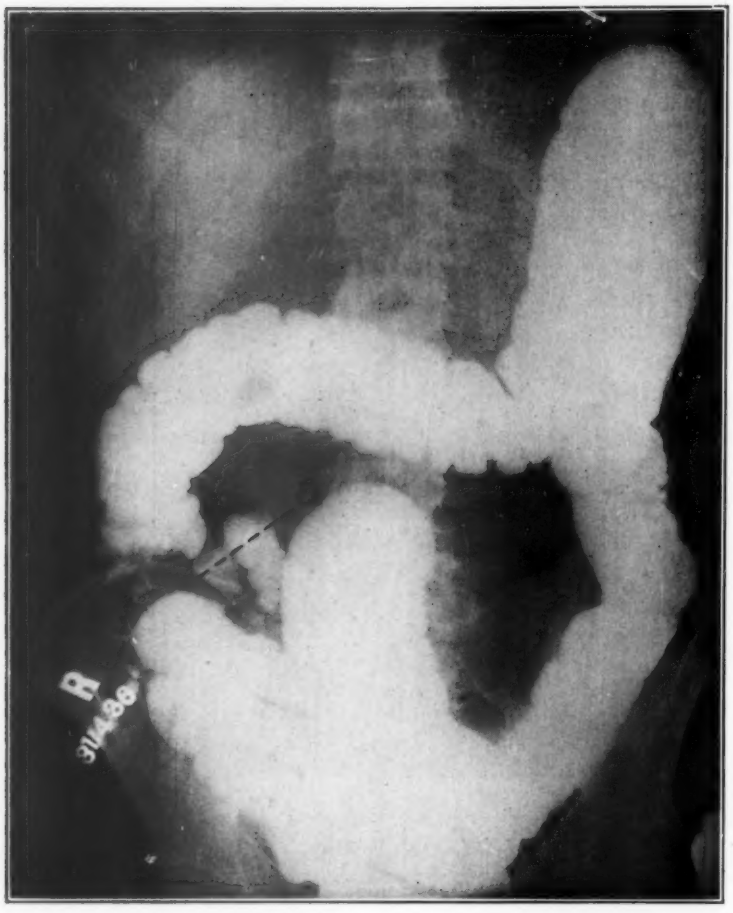

FIG. 6. (Case 311436.) Filling defect in the cecum at "a".

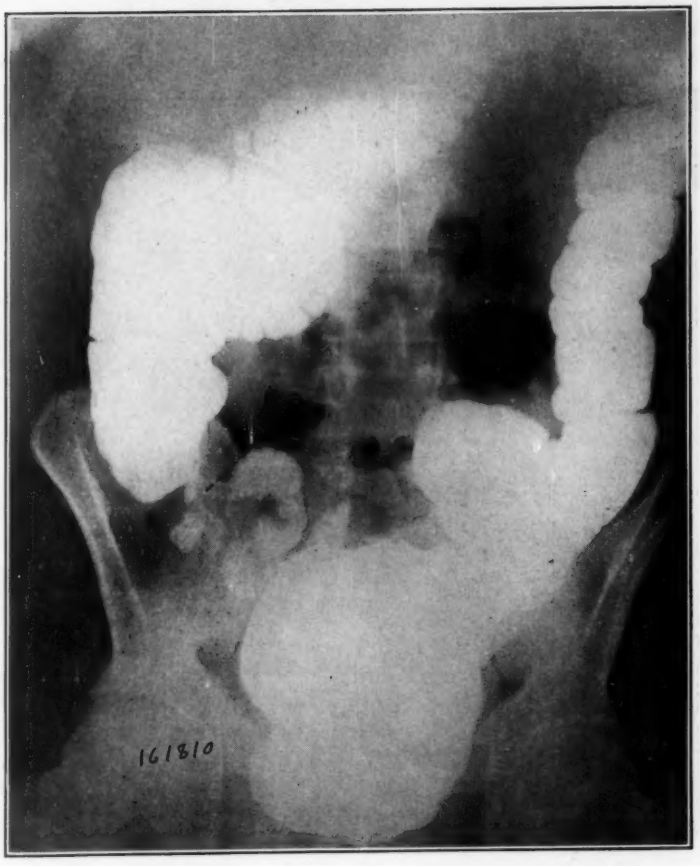

FIG. 7. (Case 161810.) Filling defect in the cecum at "a".

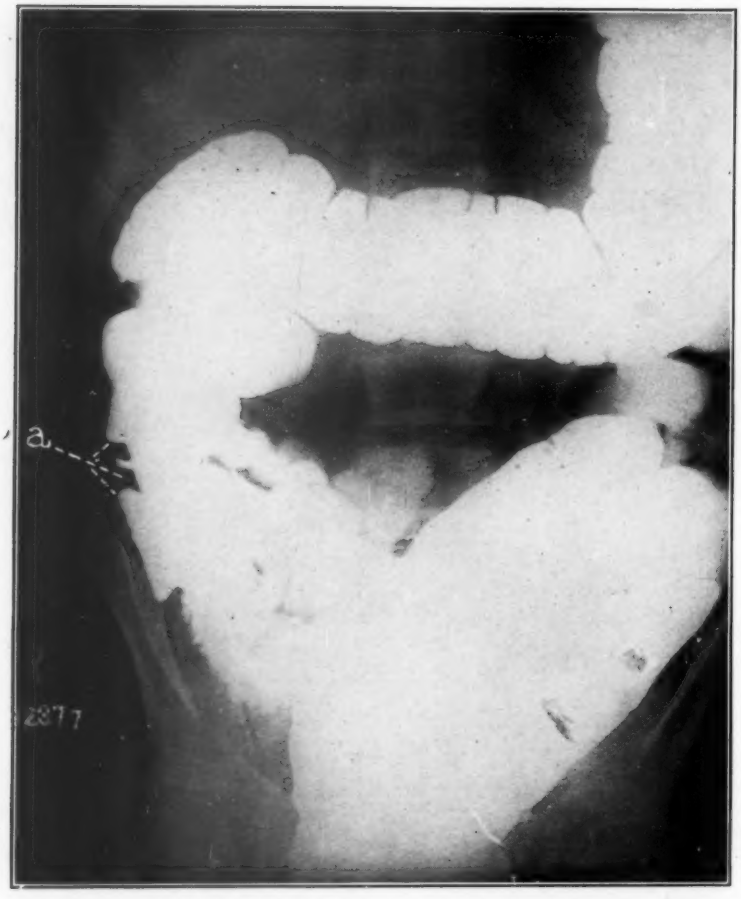

FIG. 8. (Case 282377.) Filling defect, outer aspect of the ascending colon at "a".

FIG. 9. (Case 282377.) Same case as shown in Figure 8. Second examination. Filling defect inner aspect of the ascending colon at "a".

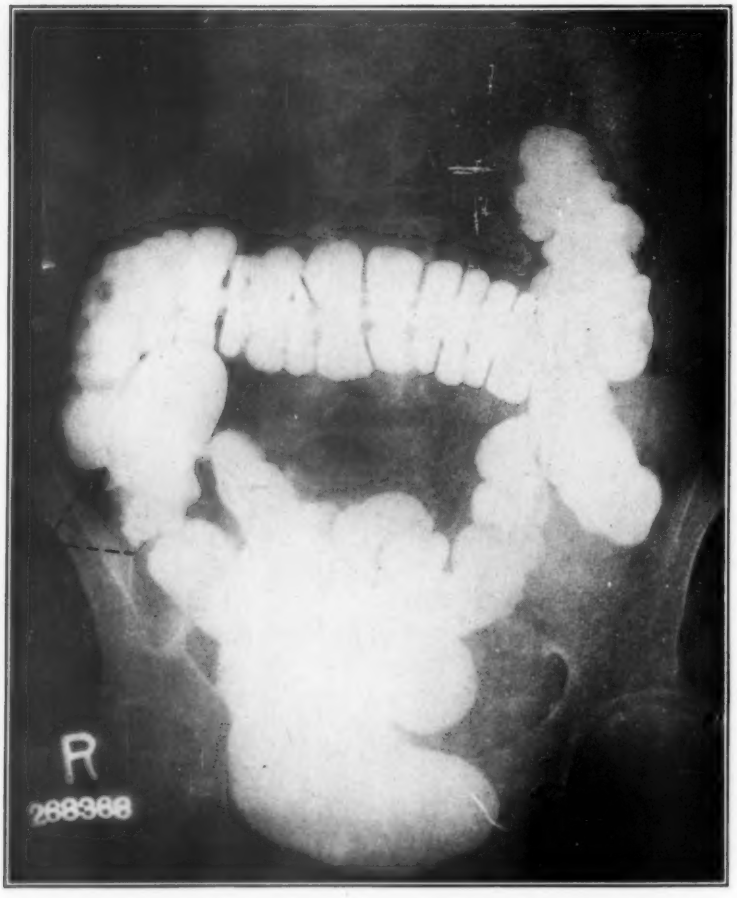

FIG. 10. (Case 268368.) Filling defect in the cecum at "a".

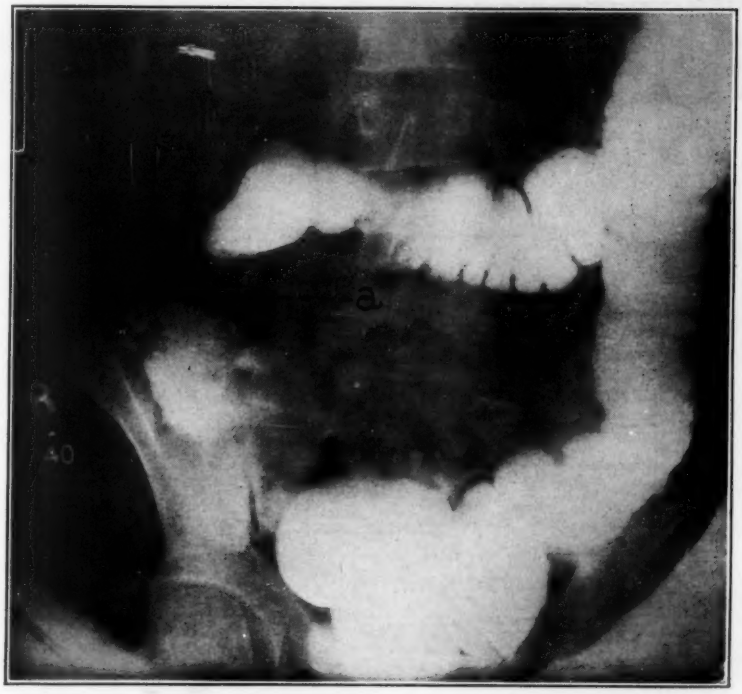

FIG. 11. (Case 310140.) Filling defect in the cecum at "a".

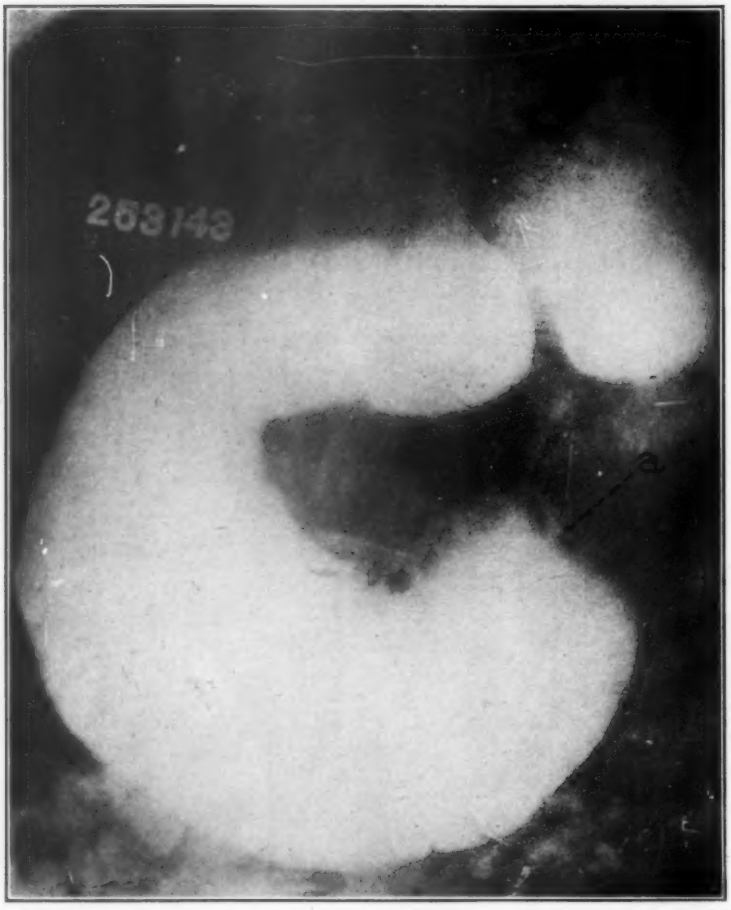

FIG. 12. (Case 253143.) Obstruction of the third portion of the duodenum at "a".

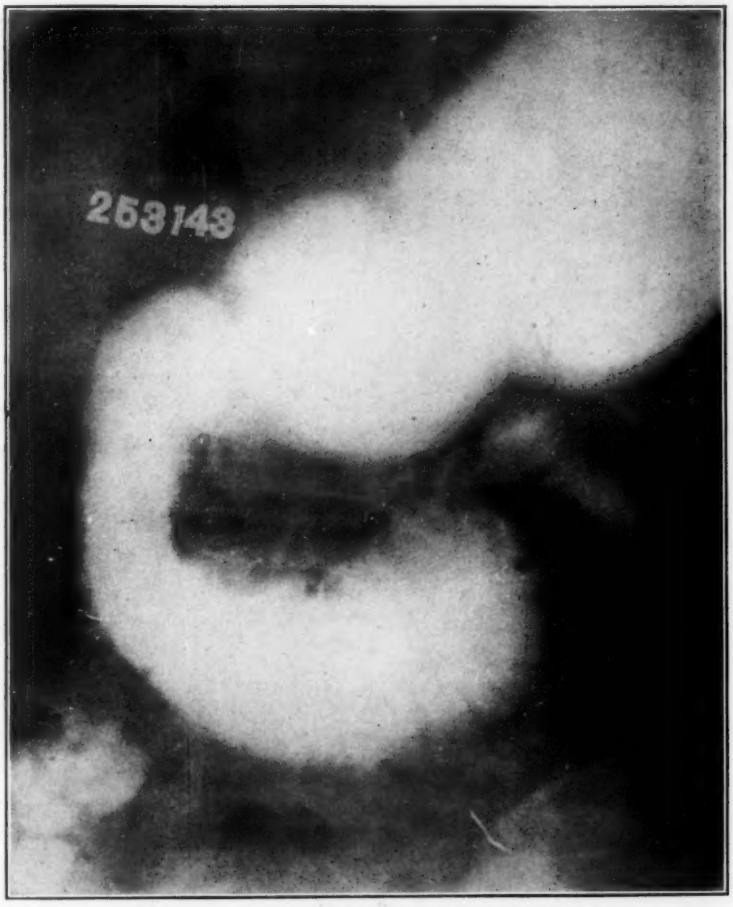

FIG. 13. (Case 253143.) Same case as shown in Figure 12, reverse peristalsis of the duodenum.

FIG. 14. (Case 283098.) Filling defect in cecum and ascending colon at "a".

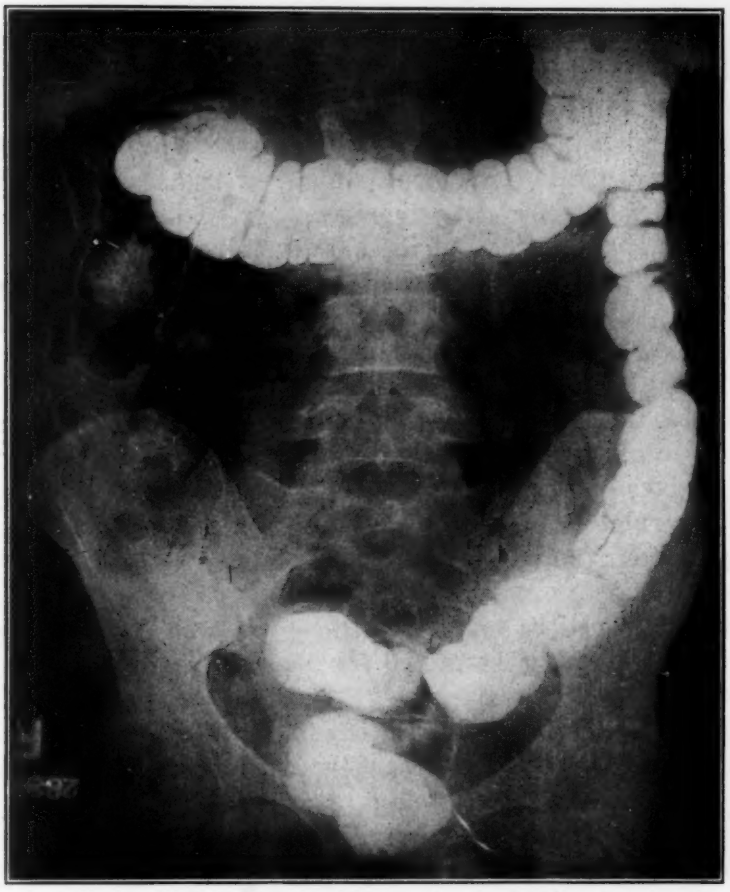

FIG. 15. (Case 283098.) Same case as shown in Figure 14. Absence of physiologic barium shadow, cecocolon at "a".

X-RAY TREATMENT OF MALIGNANCY

A. P. Overgaard, M. D.
Omaha

Upon the introduction of the Coolidge tube, early in 1914, we began to use aluminum and sole leather to filter out the alpha and beta rays which had been causing our burns. Deeper penetration was sought and new transformers were built especially for deep therapy work. These gave us a ten-inch spark instead of the old seven-inch.

This added penetration was the most important development of the new tube for by careful cross-fire methods we could now deliver a full dose of rays where we wanted them.

Today, I am using a nine-and-one-half-inch back-up spark with five millimeters of aluminum and sole leather at a focal distance of eight inches and run six milliamperes current. This gives an erythema dose in eight minutes.

As a rule, we give three erythema doses in one day and require four to five days to cover a chest thoroughly. After such a complete ray, the patient is sent home for three weeks with orders to rest and keep on a light diet. She should, preferably, be in bed for a least a week after each series.

This system of applying the ray to a post-operative breast cancer case is repeated at least three times and if any signs of metastasis are then found, a fourth or fifth series is given. Then the patient is ordered to report at least once every three months for two years for an examination by fluoroscope to check up the lungs and mediastinum.

It is practically impossible to remove all the glands in the tissues by operation. These missed glands cause recurrence. Every cancer cell not removed is bound to grow again. So we need to be very thorough in our treatment.

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*Presented before the Omaha Roentgen Society, Omaha, March 27, 1920.

To produce the required effect in some cases enormous doses must be used.

Rare cases may require less. It depends upon the patient. The ray has a different effect on each one. I have found that a few could take two or three times an erythema dose and get only a slight reaction. Others get a marked reaction from an eight-minute dose.

Iodine used on the skin before the application of the ray will produce a severe reaction at once. Therefore it should never be used when a treatment is to be given. Always bear this in mind when a case presents itself for treatment immediately after operation.

The question of reaction is a serious phase of the practice of deep therapy. Constitutional effects must be recognized and then alleviated when possible. Baclere in a discussion of the effects of roentgen and radium therapy uses the term "Penetrating-Irradiations-Sickness" to include disturbances caused by the two agents, since they are practically the same, although symptoms vary in patients and at different times in the same patient.

Sickness produced by deep roentgen therapy ranges from general discomfort and languor lasting a few minutes or a few days, to loss of appetite and violent vomiting with nausea lasting as long as two weeks. These symptoms may come on at once or not until the next day. Women suffer more from this cause than men.

Reasons for the sickness are still obscure. However, the more completely gases are eliminated from the treatment room and absolutely pure, fresh air provided, the more the symptoms are reduced. In our office, a special fan is installed in the wall to exhaust the impure air. The patient's face is covered with a leaded rubber apron as is also the chest and abdomen not undergoing treatment at the time.

The inhalation of gases produced by the action of high tension wires upon the air must be largely responsible for the constitutional by-effects of the ray since the operator and his assistants are often similarly affected. However,

this hypothesis is denied by Jones, Ewing, and others who believe that nausea results only when the breast or the lower part of the chest is treated with large doses. Roth attributes the by-effects to an irritation of the vagus nerve.

The feeling of dryness in the mouth, excessive thirst, the presence of a brassy taste, and the change in the flavor of foods indicate that the salivary glands and others in their region are affected. The *x*-rays have been found also to affect the ganglionic sensory nervous system which might account in part for the condition as it resembles drunkenness or sea-sickness.

Such reflex symptoms are known to occur at times through the vascular system when arterial blood becomes loaded with a substance such as tartar emetic. The novice's first cigar may thus produce nausea and vomiting. When the sickness is delayed until the day after the treatment, by-effects may be the result of the formation of emetic substances gradually passing into the blood.

Whatever its cause, the penetrating-irradiations-sickness prevails in spite of all precautions and will probably increase with the increased use of the Coolidge tube. The intenser radiation and greater penetration of these otherwise superior tubes and the dosage possible with them cause a much more rapid and massive cellular destruction and consequently greater adulteration of the blood by toxic substances.

Russell H. Boggs laments the inadequate therapy given by a large majority of roentgenologists in the post-operative treatment of carcinoma of the breast. "First," he says, "they leave many chains of lymphatics untreated. And second, while they give a physiologic dose superficially, in cross-firing they employ too few ports of entry, so that as a result the deep tissues receive only one-third to one-seventh the physiological dose."

Every roentgen therapeutist should make a comprehensive study of the lymphatics draining the breast before he attempts to treat mammary carcinoma. The lymphatic

supply to the breast is greater than to almost any other organ and we learn from the study of bone metastases how extensively the lymphatics become involved. From this, we realize that when we ray only the line of incision, axilla, and supraclavicular region, our treatment is very incomplete. We should never neglect to ray the internal mammary glands, since it is from these that the involvement from one breast to the other takes place.

Autopsy has shown that the liver of all internal organs is the most frequent seat of metastases and often becomes involved in quite early stages. Handley attributes this to cancerous dissemination along the lymphatics of the fascia of the thoracic wall to the epigastrium and the umbilicus, whence these cells follow the lymphatics and are deposited on the surface of the liver or are carried on to the portal glands.

Next in frequency to be involved are the lungs, pleura, and glands of the mediastinum. The intercostal lymphatics are responsible here. Next comes the pelvic viscera, involved in about eight per cent of early cases in young patients and in four per cent of older patients. To account for the lower percentage, we again look to the lymphatics which with age undergo senile atrophy.

Overwhelming evidence proves the lymphatics to be the chief agent of cancer dissemination. In the aged and in thin patients where the vessels are smaller, the advance of metastases is less rapid. If the roentgen rays did nothing more than produce a sclerosis of the lymphatics and a reduction of the size of the vessels, the treatment would at least check the progress of the disease and in some cases effect a cure.

In view of the wide distribution and depth of metastases, we know that in treating carcinoma of the breast the rays must be so directed that the deep glands in the axilla, under the clavicle, in the mediastinum, those leading to the liver, and all the viscera which invite metastases through the lymphatics will receive a full roentgen dose employed so

that the deep glands will be given from three to seven times the amount that is given to any skin areas.

Pfahler in a recent article on Malignant Disease of the Lungs advances the theory that when the lungs are involved it must always be looked upon as a part of a general carcinomatosis and treated as such. His conclusions are,

1. Primary malignant disease of the lung is rare.
2. Metastatic malignant disease of the lung is common and should always be looked for in connection with advanced malignancy.
3. A roentgenological examination of the chest should be made in every case of carcinoma of the breast referred for operation or roentgenotherapy and he would look to an earlier recognition of the disease.

For, more and more, we realize that best results come only when the ray is applied early. On an open wound it is productive of rapid healing and the more quickly it is applied to the parts which may still retain cancer cells, the better. I recommend the first treatment within a week after operation or as soon as the effects of the anesthetic are past. This is the only safeguard against recurrence.

I am convinced from the cases I have seen during the past five years that proper post-operative treatment will now prevent from twenty-five to fifty per cent of recurrences even in early cases, because cancer cells can be destroyed at a greater depth and distance from the original growth. And I agree with Deaver that it is only a question of time until the profession will realize that post-operative treatment is just as necessary after the operation as is asepsis before and during the operation.

Have seen splendid palliative results from radiation and find no cause for discouragement as an encouraging number are living today and show no recurrence.

In closing I shall review, briefly, with lantern slides ninety typical cases treated and their results. The majority of these cases came to me for treatment within a month following operation.

NO.	SEX	AGE	DISEASE	HISTORY	DATE OF TREATMENT	RESULTS
1.	Female	53	Breast cancer	Post-operative	July, 1915	Died April, 1917, of typhoid
2.	Female	35	Breast cancer	3rd operation in 2 yrs.	July, 1915	Died 5 mo. later, general metastasis
3.	Female	46	Breast cancer	Post-operative	July, 1915	Died April, 1916; apoplexy, no recurrence
4.	Infant	11m.	Sarcoma eye	1 mo. duration	July, 1915	Died; no improvement
5.	Female	50	Breast cancer	Post-operative	Jan., 1916	Jan., 1918, slight recurrence; living and well
6.	Male	27	Sarcoma of testicles	2nd operation 2 weeks after first	Feb., 1916	Living
7.	Male	37	Sarcoma lip	Post-operative		Living
8.	Female	34	Breast cancer	Post-operative	April, 1916	Died June, 1917, metastasis
9.	Female	62	Breast cancer	Post-operative	May, 1916	Living
10.	Female	50	Sarcoma of sternum	Several years duration	July, 1916	Relieved, then recurrence; died
11.	Male	72	Cancer of mouth	3 months duration	Sept., 1916	Died
12.	Male	79	Cancer of axilla	Followed operation	Oct., 1916	Died year later from recurrence in spleen
13.	Male	54	Cancer of tongue	Several years duration	Oct., 1916	Died
14.	Male	76	Cancer of parotid gland	6 months duration	Nov., 1916	Died March, 1917
15.	Female	78	Cancer of breast	Lump in breast; too weak for operation	Nov., 1916	Living and well
16.	Male	57	Hodgkins disease	Several operations, then recurrence	Nov., 1916	Died 1919
17.	Female	58	Cancer of breast	Post-operative	Nov., 1916	Died of a fall resulting in metastasis, 1917
18.	Female	46	Breast cancer	Post-operative	Nov., 1916	Died
19.	Female	42	Cancer of mouth	Post-operative several months before ray was used		Living and well
20.	Male	65	Cancer intestines	Post-operative	Nov., 1916	Died February, 1917
21.	Male	80	Cancer, neck	Post-operative; 2 yrs. later *x*-ray	Nov., 1916	Recurrent; died Feb., 1918
22.	Female	36	Cancer of axilla	2 years duration	Jan., 1917	Recurrent; died
23.	Female	67	Epithelioma forehead	Post-operative	Feb., 1917	Living
24.	Female	40	Cancer of breasts and neck	Post-operative, paste used, then recurrence, then rayed	Feb., 1917	Living and well
25.	Female	42	Cancer of breast	Post-operative	Feb., 1917	Well and living
26.	Male	40	Cancer of lip	*X*-ray only	Aug., 1916	Living and well
27.	Male	75	Cancer of face	Year duration	Mar., 1917	Died
28.	Female	75	Cancer of eyelid	Years duration	Feb., 1917	Living and well
29.	Male	67	Leukoplakio	Years duration	Mar., 1917	No report
30.	Male	62	Cancer	Metastic	Mar., 1917	Died
31.	Male	17	Cancer in ethmoid cells	2 weeks duration, metastic	Mar., 1917	Died in 3 weeks
32.	Female	60	Epithelioma of cheek	Several years duration	April, 1917	Living
33.	Female	37	Cancer of breast	Post-operative	Nov., 1915	Living
34.	Female	52	Cancer of breast	Recurrence, post-operation, then *x*-ray	May, 1917	Living
35.	Male	77	Cancer of nose	Several years duration	May, 1917	Living
36.	Female	47	Cancer of breast	Post-operative	June, 1917	Living
37.	Female	13	Sarcoma of sternum	2 months duration, then *x*-rayed	July, 1917	Living
38.	Female	55	Cancer of breast	Post-operative	Aug., 1917	Died December, 1917
39.	Female	49	Cancer of breast	Post-operative	Aug., 1917	Living
40.	Female	60	Cancer of breast	Post-operative	Aug., 1917	Died August, 1918
41.	Male	44	Cancer of neck	Post-operative, 2 yrs. interval before recurrence, then *x*-ray	Sept., 1917	No report
42.	Female	58	Cancer of breast	Post-operative	Oct., 1917	Died May, 1918
43.	Female	39	Cancer of breast	Both breasts removed	Nov., 1917	Living
44.	Female	70	Cancer of nose	Several years duration	Oct., 1917	Living
45.	Female	46	Cancer of upper gum	Several years duration	Oct., 1917	Living
46.	Female	32	Cancer of breast	Post-operative	Oct., 1917	Living
47.	Female	40	Cancer of both breasts	Post-operative	Dec., 1917	Living

NO.	SEX	AGE	DISEASE	HISTORY	DATE OF TREATMENT	RESULTS
48.	Male	45	Cancer of lip	Post-operative	Dec., 1917	Living
49.	Female	69	Epithelioma of face	X-ray only	Dec., 1917	Living
84.	Female	50	Cancer of breast	Post-operative	Dec., 1917	Living
51.	Female	63	Epithelioma	X-ray only	Jan., 1918	Living
52.	Male	48	Epithelioma of face	X-ray only	Jan., 1918	Living
53.	Female	50	Cancer of breast	Recurrence	Jan., 1918	Living
54.	Female	43	Cancer of stomach	Post-operative	Jan., 1918	Dead
55.	Male	26	Cancer of stomach	Post-operative	Feb., 1918	Dead
56.	Male	41	Cancer of eyelid	X-ray only	Mar., 1918	Living
57.	Male	48	Sarcoma of thigh	Post-operative	Mar., 1918	Died of pneumonia
58.	Male	48	Sarcoma of axilla	Post-operative, recurrence	Mar., 1918	No report
59.	Female	50	Cancer of breast	Post-operative	Mar., 1918	Living
60.	Female	50	Cancer of breast	Post-operative, recurrence	Mar., 1918	Living
61.	Female	56	Cancer of breast	Operated, recurrence	April, 1918	Living
62.	Male	43	Epithelioma of nose	Several years	April, 1918	Living
63.	Female	66	Epithelioma of nose	Several years	Mar., 1918	Living
64.	Female	30	Epithelioma of nose	Several years	May, 1918	Living
65.	Female	37	Cancer of nose	Several years	June, 1918	Living
66.	Female	43	Cancer of breast	Post-operative	June, 1918	Living
67.	Female	52	Suspected cancer of breast	X-ray only	June, 1918	Living
68.	Female	66	Cancer of breast	Post-operative	June, 1918	Died April, 1919
69.	Male	32	Sarcoma of sternum	2 months duration	Aug., 1918	Living
70.	Female	54	Cancer of thyroid	Post-operative	Aug., 1918	Died
71.	Female	54	Sarcoma of leg	Recurrence	Sept., 1918	No report
72.	Male		Lymphatic sarcoma of neck	Post-operative	Sept., 1918	Living
73.	Female	47	Cancer of breast	Post-operative	Oct., 1918	Living
84.	Female	50	Cancer of breast of breast	X-ray only	Dec., 1918	Living
75.	Male	70	Cancer of neck	Post-operative	Jan., 1919	Died April, 1919
76.	Male	36	Lymphatic sarcoma of neck	1 month's duration, x-ray only	Dec., 1918	Died May, 1919
77.	Male	73	Cancer of lip and neck	Recurrence	Feb., 1919	Dead
87.	Male	43	Epithelioma of face	X-ray only	Mar., 1919	Living
79.	Female	32	Cancer of uterus	X-ray following radium	April, 1919	Died
80.	Male	62	Cancer of neck	Recurrence	May, 1919	No report
81.	Female	30	Cancer of stomach	Several years duration	May, 1919	Died
82.	Male	42	Cancer of stomach	3 months duration	May, 1919	Died
83.	Male		Cancer of neck	Post-operative	June, 1919	Living
84.	Femael	50	Cancer of breast	Operated, recurrence	July, 1919	No report
85.	Female	61	Cancer of breast	Post-operative	July, 1919	Living
86.	Female	77	Cancer of axilla	Post-operative	Sept., 1919	Died
87.	Male	43	Epitheolma of face	X-ray only	Jan., 1919	Living
88.	Male	29	Adenoma both sides of neck	X-ray only	Nov., 1919	Living
89.	Male	65	Epithelioma of face	X-ray only	Nov., 1919	Living
90.	Male	24	Sarcoma	X-ray only	Nov., 1919	Living
91.	Male	63	Cancer of jaw	recurrence	Nov., 1919	Living

PHYSICAL FACTORS UNDERLYING THE USE OF RADIUM AND RADIUM EMANATION

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Chicago

II. THE USE OF RADIUM EMANATION

In a previous paper the course of the disintegration of radium was discussed both with reference to the rays emitted, and to the complex series of radioactive elements which result. It was pointed out that the alpha rays, while they are the most powerful, are practically useless because of their extremely low penetration, and that for therapeutic purposes only the gamma rays are useful. Hence it is obvious that the radium itself is of no therapeutic use, except as it furnishes Radium B and C, for the gamma rays come only from these two elements. Since the only function of the radium is to produce Radium B and Radium C, it would be advantageous to keep the costly radium in a secure place and to extract from it these active elements.

This can readily be done by employing the physical properties of the radium emanation. As has been stated, this is a gas analagous in every way to the gases of the zero group of the periodic system, such as neon and argon. Because of this fact it can easily be separated from radium. Solid radium salts lose their emanation constantly and slowly, but not completely. In order to drive the emanation entirely from a radium salt, the latter must be heated to a high temperature. When, however, a radium salt is dissolved in water, the emanation collects in the water and above it, and it may readily be pumped out and sealed into containers for use.

During the conversion of radium into the emanation only alpha rays are emitted. The gamma rays are thus still to

come in subsequent changes, and if the emanation is sealed into small tubes it will there disintegrate to give Radium A, B, and C, and the tube will thus rapidly become a source of gamma rays.

The Extraction Apparatus

The apparatus in which the pure radium emanation is extracted is shown in Figure 1. This was originally designed by Dr. William Duane of the Harvard University Cancer Commission, and with several modifications is now in wide use. A is a glass flask containing the radium salt dissolved in weak hydrochloric acid. Because of its value this flask may well be kept in a safe, and of course should be set within another glass vessel as a precaution in case of accidental breakage. From this flask a glass tube leads to the rest of the apparatus through a long vertical glass tube which should be more than 760 mm. in length, in order that the flask A may be completely evacuated without causing the mercury from the bulb C to reach as high as the trap at B. DC and HG are pumps. At N the glass capillary tube into which the emanation is to be sealed, is connected by a direct seal to the glass. A powerful suction pump is connected at M, the mercury in K being lowered by applying a slight suction to the bulb L. The entire system is thus evacuated from M, with the stopcock I open and the mercury in G so low that there is open connection with the purifying chamber at F.

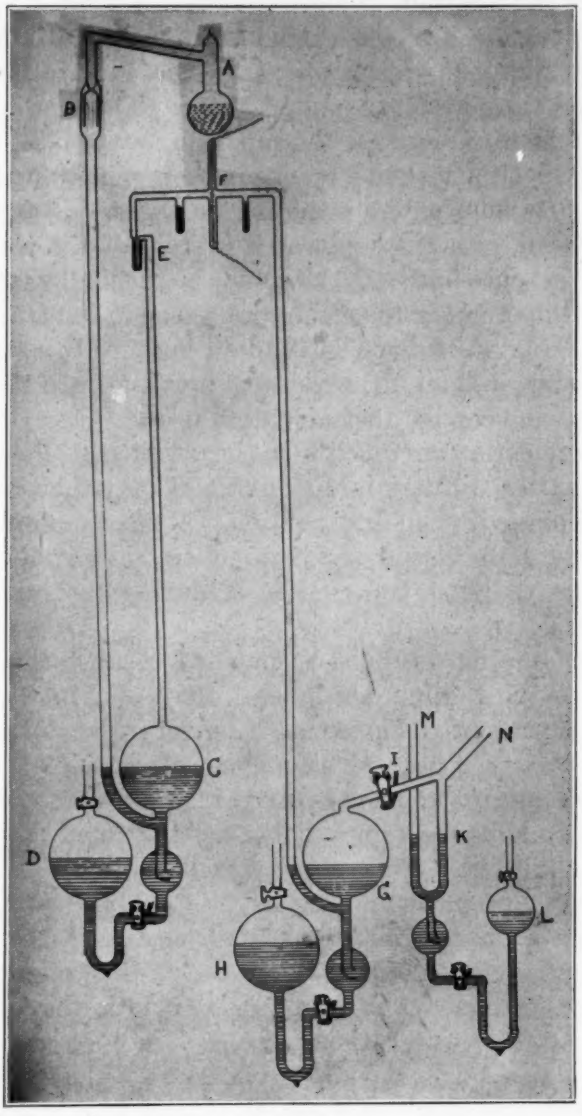

FIG. I

To collect the emanation the apparatus is allowed to stand any desired length of time with the mercury in C raised as shown in the diagram to close the flask A from the rest of the apparatus. For the extraction the rest of the apparatus, including the space above the mercury in bulb C, is evacuated through M, as stated above. The mercury in G is then raised to close off the purifying system F, and the mercury in C is lowered to open communication with the flask A. Because of the much larger volume of the bulb C as compared with A, the greater portion of the emanation diffuses at once into C. Mercury is then allowed to re-enter C, thus forcing the emanation through the trap E into the purifying system at F. While it is there being purified the mercury is again drawn down in C, the trap E serving to seal off and confine the emanation in F. When C is again in communication with A, the major portion of the remaining emanation diffuses into C, and this may then be forced into F along with the first portion. A third similar pumping by the bulb C will serve to collect practically all the emanation that has collected in A during the interval allowed.

The emanation needs to be purified because the disintegration of the radium decomposes the water in which it is dissolved. About 15 cubic cm. of mixed hydrogen and oxygen are produced per day by a gram of radium. Since the hydrogen and oxygen are evolved in equivalent quantities, they can readily be removed by causing them to combine with each other. This is accomplished catalytically by means of a thin platinum or a slightly oxidized copper wire wound on a quartz rod and heated electrically by sealing the wire through the glass of the tube F and connecting it with any lighting circuit. The recombination is rapid and complete. The water thus produced is then rapidly removed by phosphorus pentoxide in the two small side tubes. The elimination of water is essential because it would otherwise later be again decomposed by the alpha rays from the emanation and might generate high pressures in the emanation tubes.

After a very few minutes the impurities in the emanation are absorbed and the latter may then be pumped by raising and lowering the mercury in G, and is sealed in the capillary tube connected at N. While the gases as they are pumped from the radium solution have a volume of 15 cc. per day for a gram of radium, the volume of the purified emanation is very much less. A gram of radium produced in a day about 0.1 cubic millimeter or 0.0001 ccm. of the emanation. This minute volume will possess all the gamma ray activity of the radium salt, but can be condensed into very small, almost hair-like capillary tubes of only a few centimeters' length.

The Quantity of Emanation Produced

It was stated in the previous paper that of every 100 billion radium atoms one explodes per second, and that of every 500,000 emanation atoms one explodes per second. Hence when the original 100 billion radium atoms have produced 500,000 emanation atoms, the latter are exploding as fast as they are formed—one per second—and this quantity of radium can never accumulate a greater quantity of emanation. These 500,000 will of course not be the first 500,000 since these will constantly have been disintegrating. At first the accumulation of emanation will be relatively rapid, since the few then present will be slow in disintegrating. But as the figure of 500,000 is approached the speeds of formation and of disintegration become more and more equal, so that near the end of the period the effective accumulation of the emanation is very slow. About one-sixth of the final "equilibrium" quantity is accumulated in the first day, and about one-half by the fourth day. At the end of a month the equilibrium is complete.

The quantity of emanation thus accumulated by one gram of radium at equilibrium is known as one curie, and occupies a volume of 0.0006 ccm. Similarly, a milligram accumulates during a month one millicurie. Thus also, each

milligram produces 0.16 millicurie during the first day and 0.5 millicurie during the first four days after the emanation has been removed. A quantity of 100 milligrams of radium therefore produces 16 millicuries in one day, about 50 in four days, and 100 in thirty days.

According to this law of accumulation it is advantageous to pump off the emanation as often as once a day. For example, if 100 milligrams of radium are at hand, 16 millicuries may be removed after one day's accumulation. After another day 16 more will be available, but the first will have decayed to a value of about 13. Thus the two together have a value of 29. This total value must be the same as the quantity which would have been obtained from the solution at the end of the second day with no extraction on the first day. The advantage of daily pumping, however, is that, while the total quantity is the same, one whole day's use was obtained from the 16 millicuries pumped the first day.

Tabulating thus the quantities furnished by 100 milligrams in solution throughout a week, the advantage of this method is obvious.

	SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.	SUN.	MON.
Value each day	16	13	11	9	8	6.5	5.5	4.5	4
in millicuries		16	13	11	9	8	6.5	5.5	4.5
			16	13	9	8	8	6.5	5.5
				16	13	11	9	8	6.5
					16	13	11	9	8
						16	13	11	9
							16	13	11
								16	13
									16
Total to date	16	29	40	49	57	63.5	69	73.5	77.5

The total quantities represented by the combined activities of all tubes on hand on any day represent the amount of emanation which could have been extracted on that day if none had been taken from the radium in the interval. Thus after a day about one-sixth is available; after four days, one-half; after a week, about three-fourths; after two

weeks, about 90 per cent, and after a month practically the entire equilibrium quantity of 100 millicuries. The figures are only approximate, and do not allow for the inevitable loss of about five per cent in the process of extraction.

After a week each tube has decreased to about one-fourth of its original activity, and in the cases cited is too weak to be of much therapeutic value. Several such tubes are then conveniently mounted together in a frame or on a strip of tape to give an applicator of their combined value but distributed over a greater area. Or they can, with proper apparatus, be opened and their combined contents can be introduced again into a single tube with practically no loss. In the continuous use of the emanation extraction apparatus with daily removal of the gas 92 to 96 millicuries would at all times be available, distributed in tubes of various strengths as indicated. In the case of larger quantities of radium the quantities of emanation would of course be proportionately increased.

In order to follow the extraction work accurately and to insure proper dosage in treatments, it is extremely desirable to have at hand one of the various types of measuring instruments. Instruments have been devised which will show on a scale reading directly in millicuries the value of each tube by simply placing it in a receiver at the proper position of the instrument. Such instruments can be conveniently used by nurses and others not skilled in radioactive measurements.

Convenience and Applications of the Emanation Tubes

The chief argument for the use of the emanation rather than the radium itself is the insurance against loss of the radium. The latter is kept securely locked in a safe and is at no time in serious danger of loss. In practice it frequently occurs that radium tubes are removed with bandages or work their way loose or are misplaced. If this happens in the case of an emanation tube there is no real loss, since the tubes have no intrinsic value and would decay to worthlessness in a few days in any case. Thus the entire gamma

ray activity of the radium is at all times available with no risk whatever.

There are, however, other arguments in favor of the use of the emanation. It can be concentrated into extremely small volume. Sixteen millicuries of emanation can be put into a tube with a total diameter of one-half of a millimeter and a length of five millimeters, which is far less than the size of a capsule containing sixteen milligrams, the corresponding quantity, of radium salt. This is often a critical factor in their application. An emanation tube can, for instance, easily be introduced into a trocar and inserted into body cavities by puncturing or otherwise, where a similar procedure in case of the large radium tube would be out of the question. Greater flexibility is also possible since the tubes can be made of any size or shape and furthermore can be arranged in applicators of any desired strength by combining tubes of various strengths either in one tube or by distributing them over any desired area.

There are several precautions which have not yet been mentioned. One is that the gamma rays do not come from the emanation itself but from the products of its disintegration; *i. e.*, from Radium B and C. Hence when the emanation is first introduced into the glass tubes it is free from these products and gives no beta or gamma rays. These rapidly develop, however, and in the course of three hours Radium A and B have reached their equilibrium quantity so that the tube is at its full gamma ray strength. Another precaution is that the tiny glass tubes are extremely fragile and should be inclosed within steel needles or other protective covering when in use. Such a needle need not exceed a millimeter in diameter and two centimeters in length, even for fifty millicuries of emanation.

Other Applications

The emanation extraction apparatus allows still further variations. In case of surface treatments it may become

desirable to make a direct application of a strongly radioactive preparation which makes use of the alpha and beta rays. For this purpose sheets of silver or of copper may be inclosed in a glass vessel, sealed at N in Figure 1, and allowed to stand in contact with the emanation for several hours. It will thus take up a deposit of Radium A, B, and C. When then removed it serves as an extremely active source of radiation while these elements last, which is about three hours. Very fine needles may thus be activated for work in confined areas.

Furthermore, radioactive preparations for intravenous or other injections may be prepared by similarly exposing sodium chloride to the emanation and allowing it to take up these active elements. The solution of the salt for injection is then temporarily strongly radioactive. Such solutions are not subject to the objections that apply to the injection of radium itself, for the question of their elimination by the system is not involved. In the course of three hours their activity dies out almost completely, and if longer treatments are desired the injection must be repeated.

Finally, in the case of massive tumors it is occasionally desirable to give a prolonged treatment. This can be done by inserting or burying the emanation tube within the mass of the tumor and allowing it to remain until its activity is lost or until the tumor is removed.

UNIVERSITY OF CHICAGO

The Portland Roentgen Club, of Portland, Oregon, was organized and held their first meeting January 14, 1920, in the office of Dr. Jos. Sternberg, Journal Building, at eight o'clock. Dr. Roy N. Payne read a paper, "Abdominal Tuberculosis"; the discussion was by Dr. Dorwin Palmer.

AN INTERESTING CASE OF FOREIGN BODY

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The following case illustrates the value of the *x*-ray where a foreign body in the tissue is suspected and emphasizes the fact that, where there is the slightest ground for suspicion, the use of the *x*-ray is imperatively indicated.

D——, six years of age, while playing with his toys, fell and injured his knee. He was supposed to have struck the patella against a small metal steamboat. The family physician treated the case for a day or two, and becoming suspicious of the presence of a foreign body, advised the parents to seek surgical counsel. Upon examination I found linear incised wound about ¼ inch in length at about the middle of the right patella, parallel with the axis of the limb. There was slight infection and moderate swelling. Palpation was negative, a probe revealed the presence of a foreign body. The *x*-ray showed the foreign body beautifully, as evidenced by plates 1, 2. On removal the body proved to be a painted circular piece of tin which was part of the little steamboat on which the child was supposed to have fallen. Fig. 3. The knee joint was uninjured and healing was prompt and satisfactory, with no subsequent disturbance of function of the knee.

PLATE 1

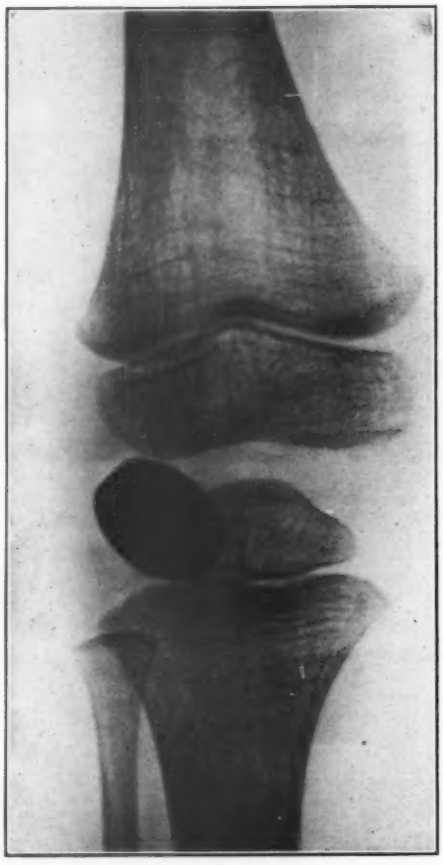

PLATE 2

PLATE 3

25 E. WASHINGTON ST.

THE JOURNAL OF RADIOLOGY

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THE JOURNAL OF RADIOLOGY is the official publication of the Radiological Society of North America, and is published monthly under the authority of the Society.

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